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Nanotechnology Markets in Global Competition: A Review

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ABSTRACT. Nowadays, nanotechnology is as a main way of in international competitiveness that is due to science and technology. Hence, nanotechnology is known as a new industry or science in the global market competition topics. Also, developed or developing countries would trend to acquire portions for future markets through the investment in nanotechnology (R&D) because of profitable products and services in the future which are consistency environmentally and green. The products or services of Nano can be supplied in different markets e.g. energy, industry, medicine, and so on. Moreover, each of them depends upon innovation in producing new features or materials for the future that can be considered as important factors for different solutions for problems of life and humanity. Most of big companies pursue nanotechnology business in the global market from different products and services through the intensive competitions especially energy sector in the future. Although it can be accounted as new business in the future, there are some weakness of the firms in competitiveness i.e. weakness in strategies, capabilities, assets and knowledge. Hence, the aim of this study is to understand variety of issues in the literature of nanotechnology and strategies from managerial views.

1. INTRODUCTION

The definition of "Nanotechnology" is due to the compound words of "Nanometer" and Nano equals that means one out of a billion in meters (Kessler & Charles, 2007). The revolution that is due to nanotechnology can change the old protocols in converting in the impact of new features. Luther (2008) presented that improving new technology causes to create new products and services. In addition, the firms will be followed appropriately, which employed nanotechnology as using new strategies in the global market. Additionally, it is using for solving variety problems in the world for different advantages like stability, steady and economical situations. Moreover, Saxton (2007) believed that employing creative techs as nanotechnology can be accounted as new infrastructures in the science for reducing costs especially from environmental aspects. Accordingly, the study of Kessler and Charles (2007) proposed that a firm should have good strategies for achieving its goals. If a firm has inflexible without innovation, so it would go in the economically worse. Additionally, formation new features causes to pay attention more because of competitions. The numbers of companies which produce nanotechnology products as well as their demands are limited. Hence, employing new technology is a necessary point in the business strategy. Accordingly, the company can get more profits through the new approaches without having any competitions as long as their competitors to start in this way. The study of Momaya (2011) has pointed out that developing nanotechnology products or features can be accounted as factors of competition in the different areas of industries because several countries invested in it for the future profits. In addition,

Momaya (2011) believed that having nanotechnology knowledge and utilizing it can be considered more from some governments for investing as economical projects in the future strategies.
According to previous researches and literatures, few studies have paid attention to nanotechnology markets. Thus, this paper provides a brief overview on the applications of nanotechnology in different aspects in the competitive market: Nano Material, Nano Machine, Nano Manpower, Nano Method, and Nano Money. In addition, it is pointed out how a company can maintain its profitable position in the global market and become superior over its competitors. Actually, nanotechnology and its applications would be focused in the current study as the main subjects.

2. IMPLICATIONS OF NANOTECHNOLOGY

Savage and Diallo (2005) as well as Shannon *et al*. (2008) proposed that the problem of global warming causes to need clean and fresh water in the early of twenty first century. In addition, this problem pressured to provide clean and fresh water in the world. Further, the demand for transportation of water as well as clean water as generation demands are higher than before. Especially, Webber (2008) stated that this problem creates fresh water resources in the world. Also, demands for energy and water will be increased because of shortage supply. Hence, the shortage of energy and water should be considered simultaneously. Some industries need to clean water for processing materials e.g. mineral extraction, chemical processing, food processing, so they are using nanotechnology. In addition, water sources are as problems in many points of the world. According to Luther (2008), suggested that nanotechnology features would be considered for solution this problem by providing potable water and clean water. Additionally, Harper (2007) proposed that using nanotechnology in the energy sector causes to save more from different aspects. Elcock (2007) believed that different source of energies that are related to nanotechnology are more useful. Although they cannot directly affect, they can contribute to response many demands from different markets. Also, they can influence in consumption pattern

3. APPLICATIONS OF NANOTECHNOLOGY

The application of nanotechnology can be considered in different sectors. So far, different literature presented that nanotechnology can be intervened to find solutions for energy problems. For example, nanotechnology can be divided some areas like Nano crystals, molecular devices, organic transistors and photonic crystals. Moreover, the R&D of firm can produce new models or products in nanotechnology and would register more than one patent, and then it can take advantage of them in the business (Kessler & Charles, 2007). Further application of nanotechnology has been stated by Scharff (2012) about the importance of food in the U.S.A from expenditure aspects of people. While the numbers of population are increased in the next few decades, it would cause to raise the demands for food in the world. On the other hand, this would be next challenge to provide food in the future. In addition, the studies like Srinivas *et al*. (2010) and House of Lords (2010) confirmed that the employing nanotechnology in the agriculture for providing food for the population in the world is inevitable. For instance, Scott and Chen (2003) presented that the applications of nanotechnology in the agriculture considered as an agenda for encountering and challenging in relevant food problems.
Another application of nanotechnology is pertained to wind energy. Since providing useful and compatible energy has an important role in the economy of the world. Nanotechnology material or products can be employed in this system e.g. durable lightweight product for rotor blades based on Nano composites, tribologically advanced covering and antiwear bearing layers and gear boxes, conductive Nano products for immunity from lightening or Nano-optimized energy stores. All of this make a better economic feeding of wind power possible in the grid (Luther, 2008). In fact, Fig.1 focuses on the producing wind energy markets as safe energy from 2006 to 2011. It presented that the market is witnessed recently increased for producing energy (Fig.1).

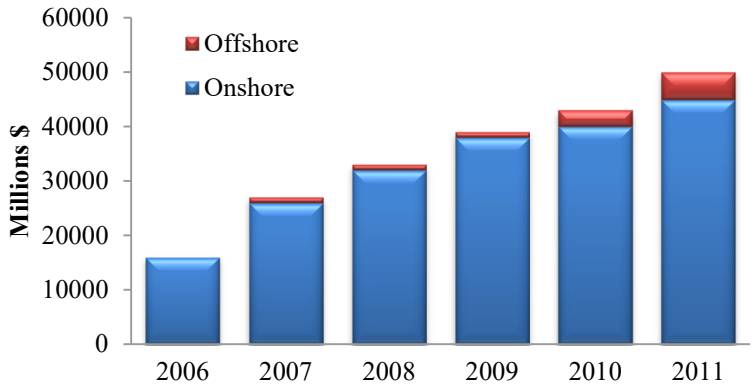

Figure 1: Annual Global Wind Energy Market
Source: Luther, 2008

The other aspect of using nanotechnology is pertained to providing energies in the future because of increasing demands in energy sector. Therefore, the renewable energies are important subjects for academic researches. For instance, Biomass creates energy and heat which can be considered as fuel. As well as Brazil is known as top producer of biofuel. Luther (2008) believed that nanotechnology can be as a new feature to convert the energies of biomass to useful energies. Also, saving and efficiency of energies are other matters which are tackle in the future problems. Lambauer *et al*. (2008) explained that this is involved with nanotechnology as intersection points of sciences for producing new features to save and produce efficient energies. In addition, nanotechnology materials or products can affect directly or indirectly in the problem of global warming and producing production more compatible with environment (Luther, 2008).

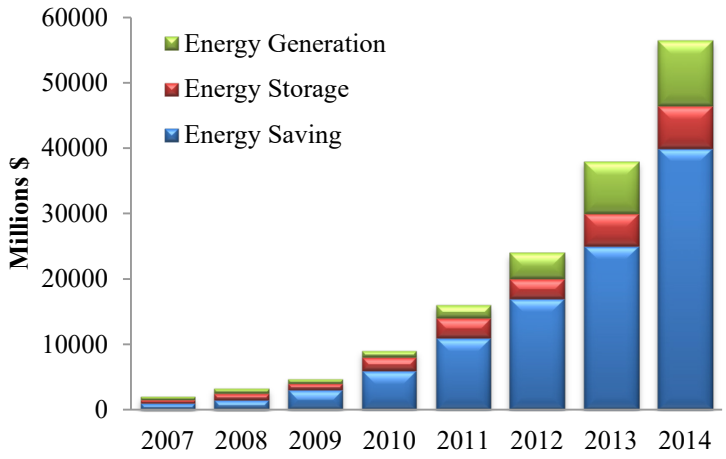

Figure 2: World Market Evaluations for Nanotechnology Applications in Energy Sector
Source: Luther, 2008

Luther (2008) noticed that the existing problems through global warming and increasing demands of energies cause to find solutions as renewable energies and supportable features. Hence, saving energies as well as efficiency of performances would be as consciousness activities for sustained life in the future. As a result, decreasing consumption of fuels by using light products in a car as well as optimizing fuel system can be contemplated as remedies for saving energy. Fig.2 shows world market evaluations for nanotechnology applications in energy sector.

4. NANOTECHNOLOGY MARKETS

Germany is known as a frontier country in nanotechnology. Also, Small and Medium Enterprises (SMEs) are occupied 70 percent of industrial works in the Germany, so the role of SMEs are very important to provide resources and share knowledge (Federal Ministry of Education and Research, 2011). In general, the market of Nano products has been grown rapidly in the recent decades. Hence, the growth of nanotechnology markets depicts that SMEs in the developing and developed countries are seek for more profits from innovation and creativity in R&D research to fulfill the gap between markets and laboratory research to commercialize (Juanola-Feliu *et al*., 2012). The growth of Nano business is presented in Table 1 and Fig.3.

Table 1: Growth of Market for Nanotechnology Applications (2009-2015)
Source: Illinois Nanotechnology Collaborative, 2012

	2009	**2015**
Nano materials	$ 9 billion	$ 19.6 billion
Nano tools	$ 2.6 billion	$ 6.8 billion
Nano devices	$ 31 million	$ 233.7 million
All Nanotechnology Products	$ 11.7 billion	$ 26.7 billion

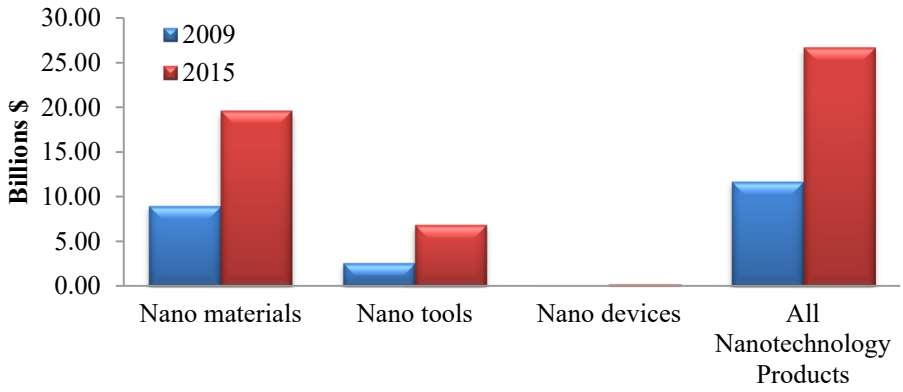

Figure 3: Growth of Market for Nanotechnology Applications (2009-2015)
Source: Illinois Nanotechnology Collaborative, 2012

In addition, it is predicted that the Nano markets would be improved from $ 2.3 billion in 2007 to $ 81 billion in 2015 (HM Government, 2010). However, the each part of Nano business has been presented form 2007 to 2015 (Table 2 & Fig.4).

Table 2: Growth of Global Revenue of Nanotechnology
Source: HM Government, 2010

Sector / Year	ICT	Automative	Aerospace & Defense	Agriculture, Food/Drink	Consumer Goods	Life Sciences	Textiles	Energy	Environment & Water	Construction	Brand & Product Security	Total
2007 ($M)	585	404	323	265	188	145	122	90	86	66	30	2304
2015 ($M)	41402	7134	3768	3210	6225	5670	2170	3615	3885	1672	2650	81401

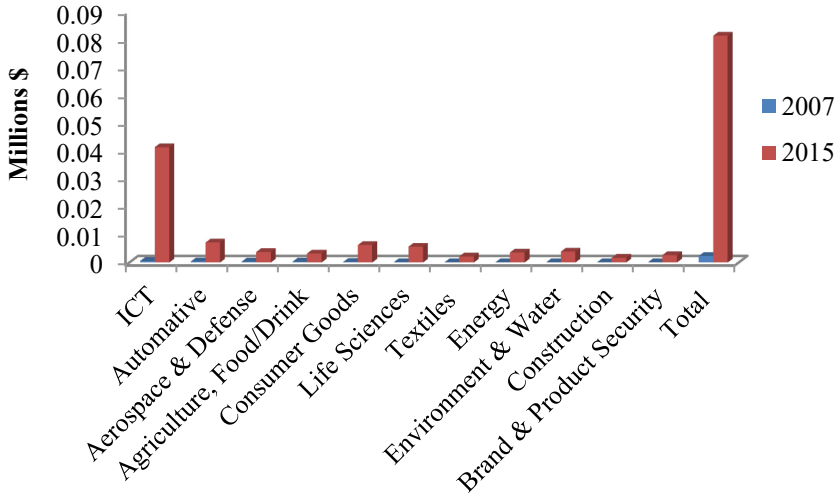

Figure 4: Growth of Global Revenue of Nanotechnology
Source: HM Government, 2010

4.1. Nano Material

Applications of nanotechnology are very powerful in capabilities to produce new materials with new features which can be used in electronics, magnetic, and optical industries. As well as, changing melting point, catalytic activities, solubility and transport influence in the producing innovated materials. However, according to report of Federal Ministry of Education and Research (2011), utilizing Nano scale materials have highly effects in resource- and energy- efficient products and features. This strategy is involved to remove noxious materials from the environment to protect as well as to help it by optimizing materials and energies. Further, employed efficient approaches are helpful for conversion, storage, and distribution of energies as using nanotechnology. Developing knowledge based bioeconomy can achieve to sustainable raw materials and energy supply via biomass. Therefore, nanotechnology could be created positive roles in improving chemical, medical, and energy industries.

4.2. Nano Machine

Innovation and creativity are components in the Nano science which are tackle in medicine, biotechnology, engineering, the physical science and information technology,etc. In addition,

Juanola-Feliu *et al*. (2012**)** deliberated about biomedical device for incessant in-vivo glucose monitoring based on nanotechnologies. In addition, they considered the role of innovations in producing new devices through the research of R&D institutes and universities (Fig.5).

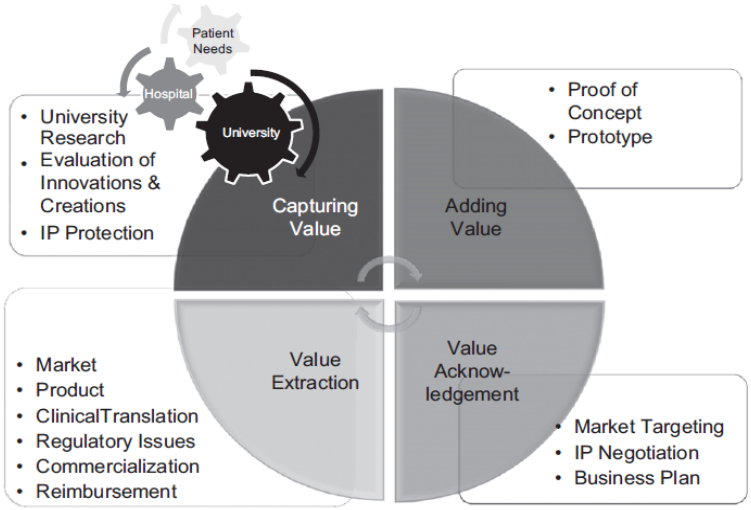

Figure 5: Overview of Value Cycle from Research to the Commercialization of a New Medical Device

Source: Juanola-Feliu *et al*. 2012

The dealings between medication and technology permit the advance of diagnostic devices to discover or check pathogens, ions, diseases, etc. Today, the combination of quick advances in areas like microelectronics, microfluidics, microsensors and biocompatible materials let the improvement of implantable biodevices e.g. the Lab-on-Chip and the Point-of-Caredevices. Consequently, incessant monitoring systems or event detectors are accessible to build up quicker and cheaper medical responsibilities—particularly while compared in the company of regular methods (Juanola-Feliu *et al*., 2012).

4.3. Nano Manpower

According to European Commission (2004) report, there are 5.68 energetic researchers for every 1000 energetic persons in Europe, compared with 8.08 in the USA and 9.14 in Japan. Captivating into description the level of human resources related with attainment the 3% Lisbon objective by 2010, it can be expected that about 1.2 million additional European research staff (including 700 000 researchers) would be required. It is necessary that procedures are locate into place to draw and keep researchers in Europe, counting the beneath exploited potential of women. Research and education have been considered in the nanotechnology strategy of Germany. Also, the government of Germany has a plan to have well-trained and specialist staff, as well as excellent research. Further, research of nanotechnology has been created new occupations. Besides, there is a mesh from professionals which they can share for achieving advanced science and economy in the future. Moreover, the universities of technical-scientific of Germany are being active in nanotechnology activities like application of nanotechnology. Further, they are focused in the impact of human and environment from the research in Nano science (Federal Ministry of Education and Research, 2011).

According to HM Government (2010) report, the nanotechnology industry in UK needs to people with adequate skills in this high value, high skilled, knowledge based market are necessary to make innovation and keep up the growth of nanotechnologies. Presently, the two most important barriers to providing of skilled forces are the lack of sufficient preparation programs and the high charge of those that act exist. According to Juanola-Feliu *et al*. (2012), nanotechnology provides interactions among variety partners such as industry, medicine, engineering, etc. Also, the university roles are key roles in the R&D research and innovations to commercialize of Nano products (Fig.6).

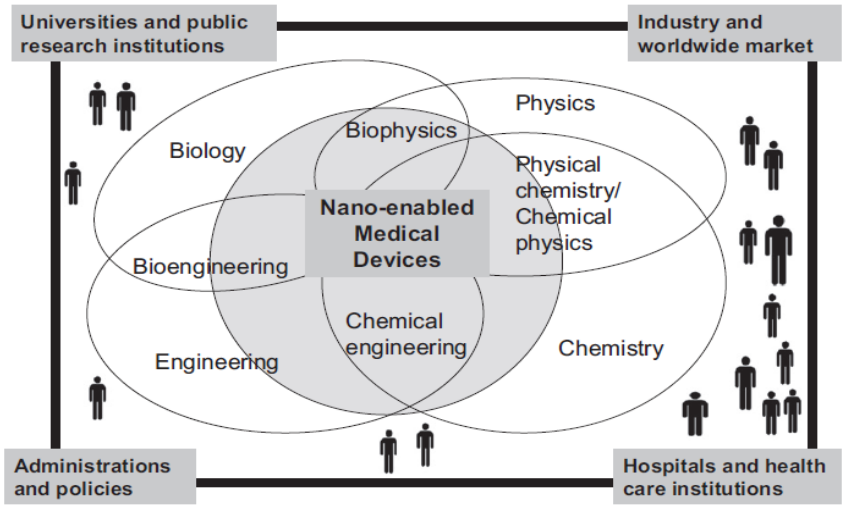

Figure 6: Innovation Ecosystem in Biomedical Engineering for Nano-enabled Medical Devices: Cross-Fertilization and Blurred Disciplines
Source: Juanola-Feliu *et al*. 2012

4.4. Nano Method

Process-based innovation needs diverse organization and commercialization strategies from those of extra frequently-studied product-based innovation. A product innovation in general considers to an assembled product, and can be sold to a purchaser while contrived, whereas a procedure of innovation enables novel products or improved cost/performance attributes in accessible products, and is at least one step removed from the final customer. A key instance of this kind of innovation is the up-and-coming division of nanotechnology. Many countries and companies have pinned prospect of increase and regeneration on the prospect that nanotechnology will make possible novel or significantly enhanced products across many sectors of the market. In2008, national governments and corporations used up over $10 billion and over $8 billion correspondingly on nanotechnology investigate and enlargement (R&D), and business enterprise capitalists invested over $1billion. But although asset in these companies is regarded as a motivation to economic increase and as an enabler of further technological innovation, slight is known about how their technologies can be profitably commercialized. The existing literature on nanotechnology commercialization does point out that the commercialization surroundings has differences based on technical strength, interdisciplinarity, standard of nature, and reliance on method of innovation (Maine *et al*., 2012).

Germany has problem with providing natural resources, so it is considered as export-oriented country as economical views. The government of Germany pursues the new markets in the future, and then it needs innovation strategy in advancing nanotechnology. Therefore, it should set whole of parts of nanotechnology through research, education, economy and politics. Hence, it is noticed in the vision as “Action Plan Nanotechnology 2015” for conforming different parts together in order to achieve the goals (Federal Ministry of Education and Research, 2011). Since there are economically and scientifically potentials from nanotechnology in the future, knowledge and its applications can be involved to new opportunities for challenges. Germany is frontier in employing efficient approaches to protect environment e.g. energy- and resource-saving through innovation and research. It can influence in producing new productions, new materials and components (Fig.7).

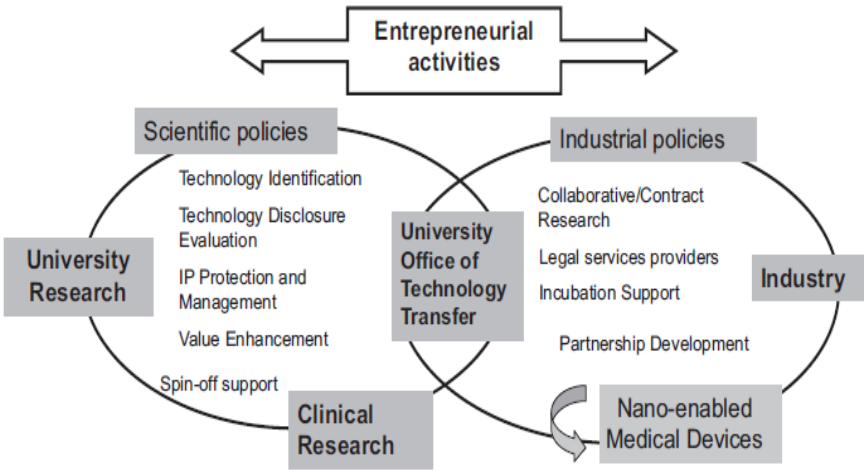

Figure 7: Overview of Main Actors and Activities involved into the Technology Transfer Process of Public-Funded Research
Source: Juanola-Feliu *et al*. 2012

4.5. Nano Money

According to the report from Federal Ministry of Education and Research (2011), the rank of Germany in the nanotechnology position in competitiveness is very high in the global markets. The amount of investment in nanotechnology through the government was 400 million Euros in 2010. It has fourth rank in the investment after U.S.A, Russia, and Japan. Also, from Organization for Economic Cooperation and Development (OECD) aspect, it has third rank after U.S.A and Japan. Further, enterprises of Germany invested 2.3 billion Euros which was 33 percent of European country investment from 2004 to 2006, USA invested 4.5 billion Euros which was 54 percent of whole investment as well as Japan invested 3.6 billion Euros which was 63 percent of its expenditure (Federal Ministry of Education and Research, 2011).

Captivating into report the prospective of nanotechnology, many countries are pursuing R&D programs with huge and quickly growing levels of public venture. Over the last decade there has been an outburst of interest with public venture increasing fast from around €400 million in 1997 to over €3 billion in 2003. Fig.9 illustrates publicly funded initiatives in nanotechnology. While the involvement of private R&D funding of nanotechnology cannot be exactly recognized, it has been anticipated to be close to €2 billion i.e. implying an entirety global R&D investment in nanotechnology of around €5 billion. In this background, it is important to emphasize that, with 56% of overall R&D investment from private sources, the EU lags in the rear of the USA and Japan with 66percent and 73percetn respectively (European Commission, 2004).

Japan recognized nanotechnology as one of its major explore priorities in 2001.According to Fig.8, the financial support levels announced augmented piercingly from $400 million in 2001 to around $800 million in 2003,overtaking the USA federal funding and is set to go up additional by 20% in 2004. South Korea has embarked upon an striving ten-year program with around $2 billion of public funding while Taiwan has dedicated around $600 million of public financial support over six years. China is devoting growing possessions to nanotechnology that is particularly significant captivating into description its purchasing power. Its share of international publications is rising quickly with a enlargement rate of 200% in the late 1990s and is catching up with the EU and the USA. The Russian Federation is well recognized in nanotechnology as well as several other recently Independent States. Many other regions and countries are paying rising concentration to nanotechnology counting Australia, Canada, India, Israel, Latin America, Malaysia, New Zealand, Philippines, Singapore, South Africa and Thailand (European Commission, 2004).

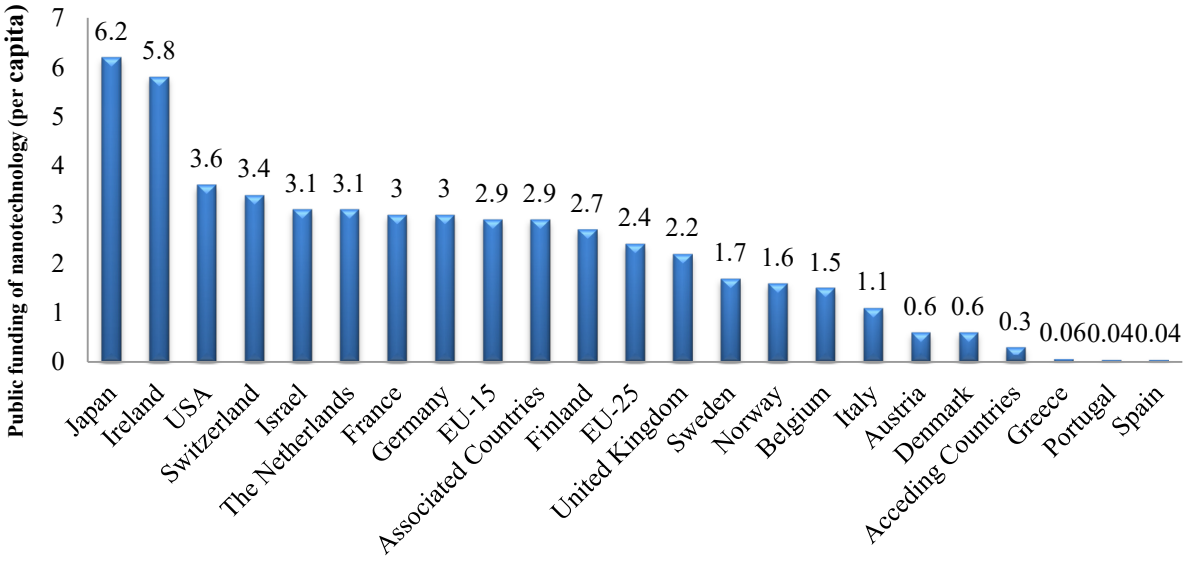

Figure 8: Ranking of Public Funding of Nanotechnology (2003)
Source: European Commission, 2004

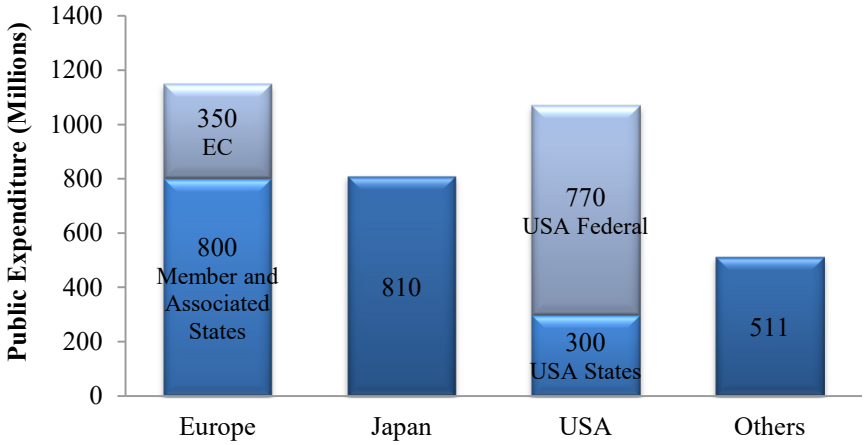

Figure 9: Public Expenditure of Nanotechnology (2003)
Source: European Commission, 2004

5. CONCLUSION

In sum up, the study of Foster (2005), Harper (2007), Elock (2007), Kessler and Charles (2007), Luther (2008), Shannon *et al*. (2008) confirmed that nanotechnology sciences can be considered for producing new products or features in order to recognize saving energies, transferring electrical energies, and providing fresh water as existing problems in the world . Consequently, implementing nanotechnology can be helpful for the future from safety, health and environmental issues for humanity. In other words, it can be considered more profitable bother suppliers and customers in the global market. Therefore, it can be influencing in the international competition as the best strategy from differentiation and cost leadership strategies.

Kessler and Charles (2007) stated that the laws of nanotechnology knowledge are less changed for improving products in these days. In addition, the strategies of suppliers conduct to depict the behaviors as the employing nanotechnology in the production from informing positive or negative aspects on the base of capabilities. Hence, increasing nanotechnology in the markets causes to create some opportunities or threats for the firms to find correctly strategies as competitions aspects in the future. Hence, the finding out the right strategy causes to improve the positions of companies in the market in the early time. The sustainable life cycle of firms is considered in the different levels from the advantages or disadvantages their business strategies e.g. generic features or patent aspects. Moreover, growing nanotechnology features are inevitable

especially in competition of industries to find more profits. As mentioned before, consistency of environment as green product or producing safe energy as well as saving in different ways of energy cause to develop products by industries in employing nanotechnology sciences.

Consequently, utilizing nanotechnology knowledge through the industries can cause to produce new products or features to get more economical and environmental benefits. The reason why its technology can assist many academic researchers as well as practitioners is very clear through the literature because it can be as a solution for reducing costs of energy sector. Nevertheless, this may be conducted in the wrong goals. But it can be used in the right aims for achieving new production or features.

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